THE CALIFORNIA WATER-USE GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT: This paper describes the organization and some of the capabilities of the geographic information system now being refined and used in the U.S. Geological Survey office in Sacramento, California. Geographic information system techniques are being used to develop, analyze, and integrate water-use and related information. Objectives of the U.S. Geological Survey's State water-use information programs address the need for both statewide and site-specific information on water use in 12 nationally determined categories. In California, the State with the largest water use in the Nation, the large volume of water used and the large number of users present major problems in meeting these objectives. The development of a site-specific data base of water-use information covering the entire State is an expensive process, requiring significant time and computer-storage space. Until a site-specific data base is developed, an interim solution is to use geographic information system techniques to integrate statewide estimates of water used in each county and hydrologic unit with localized site-specific data from various sources. Geographic information system techniques can then be used to check regional estimates of site-specific water-use data to insure that the estimates are reasonable. The combination of geographic information system tools and a relational data base also allows for rapid update of data and permits query of spatial data by user-defined geographic areas to support other aspects of water-resources modeling and forecasting.
KEY TERMS: Water use; California; Geographic information system; statewide data; site-specific data; computer mapping.

INTRODUCTION

Extensive water-use information is being collected, stored, and maintained (Templin, 1986) in a data-base management system that allows (1) establishment, analysis, and manipulation of various data components, and (2) relation of data and spatial information to locations and areas in California. In the past, these functions have required many hours of calculating, map scaling, hand plotting, and retyping of tables.

The underlying concepts behind the geographic information system (GIS) and the value of integrating various related types of mappable information to help solve natural-resource problems are not new. These principles have been used for years in hydrologic investigations of the U.S. Geological Survey, such as a report by Templin (1984), and were demonstrated by McHarg (1971) to be valuable in a host of environmental studies. GIS methods have been implemented by using computer technology, and they are now being used to establish, analyze, and integrate water-use and related spatial information. The objectives of the U.S. Geological Survey's State water-use information programs address the need for both statewide and site-specific information on water use in 12 nationally

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determined categories (Templin, 1986): water supply; sewage treatment; mining; domestic; commercial; industrial; irrigation; livestock; and four power-generation categories, hydroelectric, geothermal, nuclear, and fossil fuel. In California, the State with the largest water use in the Nation, the large volume of water used and the large number of users present major problems in meeting these water-use information objectives.

The development of a site-specific data base of water-use information covering the entire State is an expensive process that requires substantial time and computer storage space. Until a site-specific data base is developed, an interim solution is to use GIS techniques to integrate statewide estimates of water used in each county and hydrologic unit with localized site-specific data from various sources. Integration of regional estimates with site-specific data, which are more accurate, would enhance the quality of the regional estimates. For example, the knowledge of local annual variations in crop acreages and monthly variations in crop-water requirements can help in the accurate estimation of regional variations.

In these water-use applications, the GIS serves as a data-base management system and as a tool for use in aggregating, manipulating, and interpreting water-use information. The California water-use information program is currently integrating four hydrologic-investigation and data components: (1) Statewide water-use totals for counties and hydrologic units; (2) site-specific water-use information; (3) water-use information from other hydrologic investigations; and (4) information from interpretive water-use investigations. Each of these components is valuable individually, but when they are available for relational analysis with respect to other spatial data in a GIS, their utility for decisionmaking in water planning and management is enhanced substantially. This relational data base also allows for rapid update of data. The GIS tools allow combination and integration of any of these types of data and permit query of spatial data by user-defined geographic areas to support other aspects of water-resources modeling and forecasting.

This paper describes some of the capabilities of the GIS now operational in the U.S. Geological Survey office in Sacramento.

METHODS

Water-use information is available in the California water-use program at two spatial levels: (1) Statewide information, such as total withdrawals and consumptive use for each county, hydrologic subregion, and hydrologic cataloging unit; and (2) site-specific information, such as withdrawals from wells or diversions from streams at a specific location, usually identified with a unique latitude and longitude designating each site. Statewide water-use information for calendar year 1985 was obtained for all States as part of the the U.S. Geological Survey report series, "Estimated Use of Water In the United States" (Solley and others, 1988), as well as for the 1987 National Water Summary (U.S. Geological Survey, 1988). These water-use data were obtained from many Federal, State, and local agencies, and various methods of interpretation were used (a full description of the methods used to obtain and manipulate water-use data for California during 1985 is beyond the scope of this paper). The 1985 data for California were used as the starting point in developing statewide information for counties and hydrologic-unit areas, which include hydrologic subregions and hydrologic cataloging units in the National Water Use Data System (NWUDS) component of the California Water Use Geographic Information System (CALWUGIS) (fig. 1). Site-specific data input into the State Water Use Data System (SWUDS) were obtained from water-use and related projects of the U.S. Geological Survey and other agencies. The NWUDS and SWUDS data were generated in or converted to INFO files that were made compatable with ARC/INFO, the GIS used in this program (the use of brand or trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey).

As ARC/INFO "coverages" (maps with related topology and attributes for each point, line, and polygon) are created or obtained, they are stored in the "coverage" library called California Geographic Information System (CAGIS). CAGIS is a storage, indexing, and reference data base of map and graphic data. These "coverages" are copied into display work spaces in SWUDS and NWUDS for manipulation, relation to specific data, and output as base maps and other report graphics. In this way, coverages are retained in their original form, and copies are made to modify for specific uses. As new coverages are developed, they are added to CAGIS for storage and use by other investigations. More detailed information on the specific sources and types of information in each data-base component of CALWUGIS is included in Table 1.

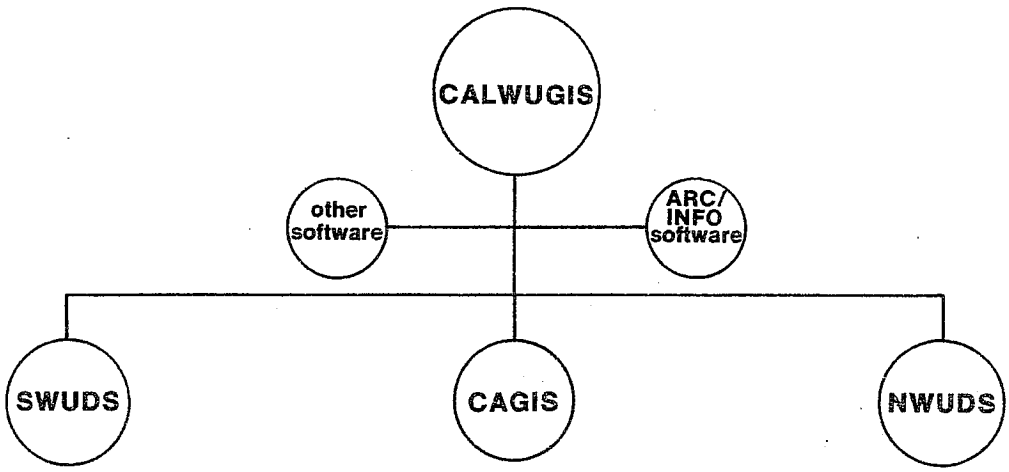

FIGURE 1. Design of the California Water Use Geographic Information System (CALWUGIS). State Water Use Data System (SWUDS). California Geographic Information System (CAGIS). National Water Use Data System (NWUDS). More detail is given in Table 1.

APPLICATIONS

GIS tools have been applied by the U.S. Geological Survey to develop, analyze, and integrate water-use information. Specific information from many hydrologic investigations and data operations within the U.S. Geological Survey and outside are effectively centralized. This centralization of information allows quality control of both statewide and site-specific data. Centralization of information also allows the synthesis of work done in particular local areas for transfer to other similar situations for use in regional estimates throughout California.

One example of site-specific data that were developed into county and hydrologic-unit area totals for 1985 is water used by hydroelectric powerplants. In California, dams with storage capacities of 5,000 acre-feet or more (fig. 2A) often have hydroelectric-power generation as one of their main purposes. Water-use estimates for the hydroelectric-power category were obtained from utility companies throughout California. Data were gathered on the location of major hydroelectric powerplants (including many plants on reservoirs with storage capacities less than 5,000 acre-feet), their water use, and their power production during 1985. The totals for each hydrologic unit and county were calculated using INFO, and the results are shown graphically (figs. 2B and 2C) for further analysis. Analysis of tabular data often can be time consuming and tedious. Graphic analysis in this program has been much more informative and an excellent quality-control technique for examining data.

Table 1: Sources and Types of Information Stored in Each Data Base Component of the California Water Use Geographic Information System (CALWUGIS).
[INFOWUDS, INFO Water-use data system.
EUOWITUS, Estimated use of water in the United States]

State Water-Use Data System (SWUDS)	California Geographic Information System (CAGIS)	National Water-Use Information System (NWUDS)
Data from hydrologic investigations on withdrawals, deliveries, releases, and returns, such as applied water irrigated acreage, crop types, and crop water requirements; California Division of Mines and Geology data on water withdrawals during oil extraction and returns of hot water for enhanced oil recovery; California Department of Health Services data on public supply well locations; California State Water Resources Control Board data on water rights, withdrawal locations and volumes, water discharge locations and volumes; Public water supply data on surface-water and ground-water withdrawals and deliveries; U.S. Geological Survey data on well locations, diversions and discharges; California Department of Water Resources data on State Water Project deliveries, dam locations, and reservoir capacities; U.S. Bureau of Reclamation data on Central Valley Project and other project deliveries; Economic data on delivery, drainage, and sewer rates; INFOWUDS site-specific base management system; ARC/INFO display work spaces for each of the above data types.	ARC/INFO coverages of county boundaries; hydrologic unit boundaries; streams, dams, water bodies; agency logos; and project base maps	EUOWITUS INFO based, water use data system; ARC/INFO display work spaces; Aggregated totals of water use and related data from various agencies, such as county totals of population, population supplied drinking water, agricultural crop and livestock production, mining operations, industrial and commercial businesses; Hydrologic unit totals are also maintained for the above types of information, as well as volumes of interbasin transfers of water.

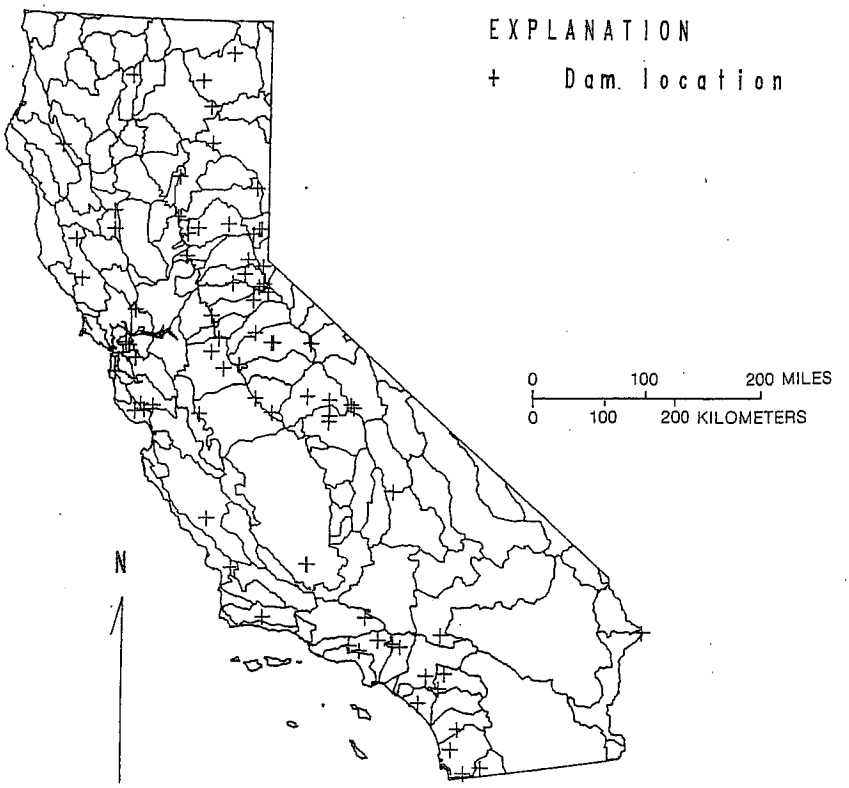

FIGURE 2A. Water Use for Hydroelectric Power Generation in California, 1985 -- Powerplants at Reservoirs with at least 5,000 Acre-Feet Normal Storage Capacities.

The choice of graphic display, however, may produce somewhat misleading results. For example, the hydroelectric powerplants along the Colorado River and in the upper Sacramento River drainage (fig. 2A) use large quantities of water. This use is displayed in figure 2B by hydrologic cataloging unit (drainage basin) and in figure 2C by county. Whereas figure 2C seems to indicate that hydroelectric powerplants use large quantities of water throughout San Bernardino and Shasta Counties, figures 2A and 2B show that only one or a few large powerplants isolated along streams within those counties give these counties large totals. Regional maps, such as figure 2B and 2C, can be useful and informative, but care is needed in choosing geographic boundaries that best present the desired information.

Graphic analysis of water use in the irrigation category (fig. 3) on two occasions identified errors in the preliminary estimations and conversion of data from hydrologic units to county totals prior to their final submission for the report by Solley and others (1988). Frequently, these errors are noticeable when the maps indicate that an area is either higher or lower in water use than would be predicted from local geography and land use.

Some examples of the integration of information from specific studies include ground-water withdrawal (pumpage) information obtained from the Owens Valley ground-water investigation (Rogers and others, 1987); ground-water withdrawals for irrigation in the Westlands Water District and in Kings and Tulare Counties (John Freckleton, U.S. Geological Survey, oral commun., 1988); ground-water use (well location and primary use of water) in Monterey County (U.S. Geological Survey Water Data Storage and Retrieval System (WATSTORE) Ground Water Site Inventory); self-supplied domestic water use in Butte County (Gene Pixley, California Department of Water Resources, written commun., 1987); and irrigation surface-water supply and demand in the selenium problem areas on the westside of the San Joaquin Valley (William E. Templin, U.S. Geological Survey, written commun., 1988). These studies, and many others, have generated water-use information that can be compared to

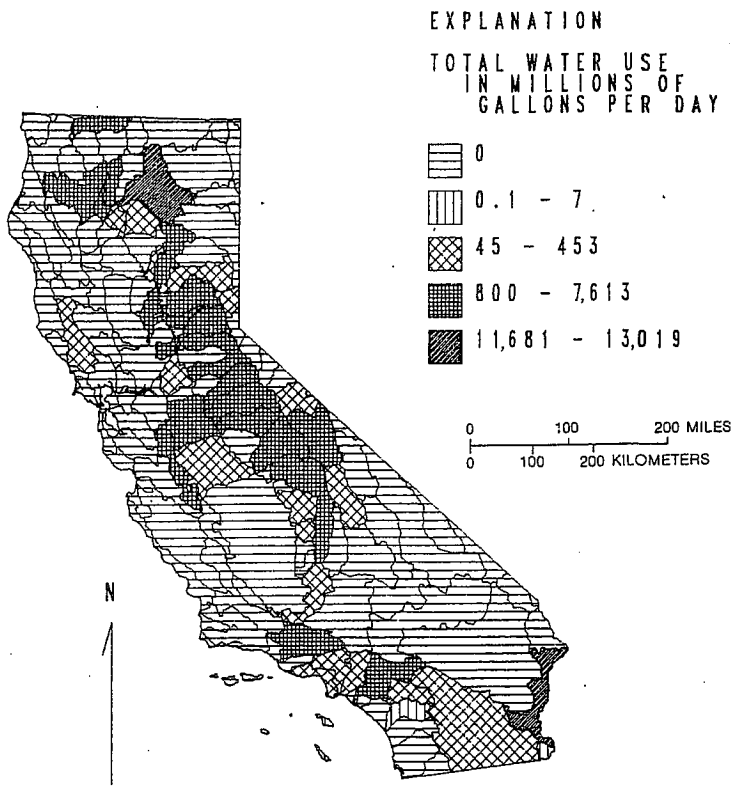

FIGURE 2B. Water Use for Hydroelectric Power Generation in California, 1985 -- Water Use by Hydrologic Cataloging Unit.

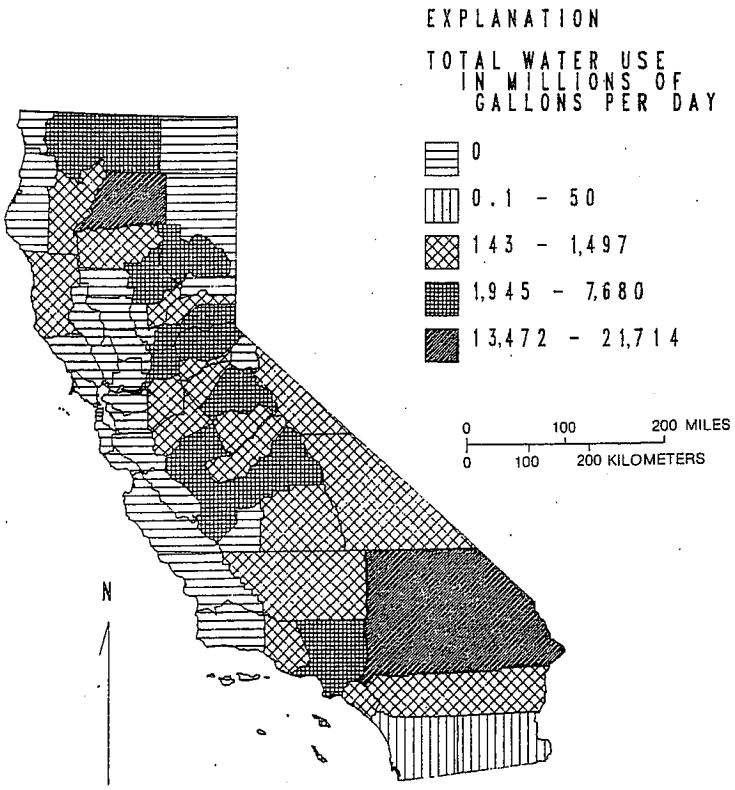

FIGURE 2C. Water Use for Hydroelectric-Power Generation in California, 1985-- Water Use by County.

regional estimates produced from methods of approximation. Examples are estimating water use on the basis of crop land use maps and using population with per-capita use rates to estimate domestic water use. The regional estimates now available serve the needs for water-use information of many hydrologic investigations within California or at least establish some limits and perspectives for initial knowledge in preparing study proposals prior to more detailed data gathering..

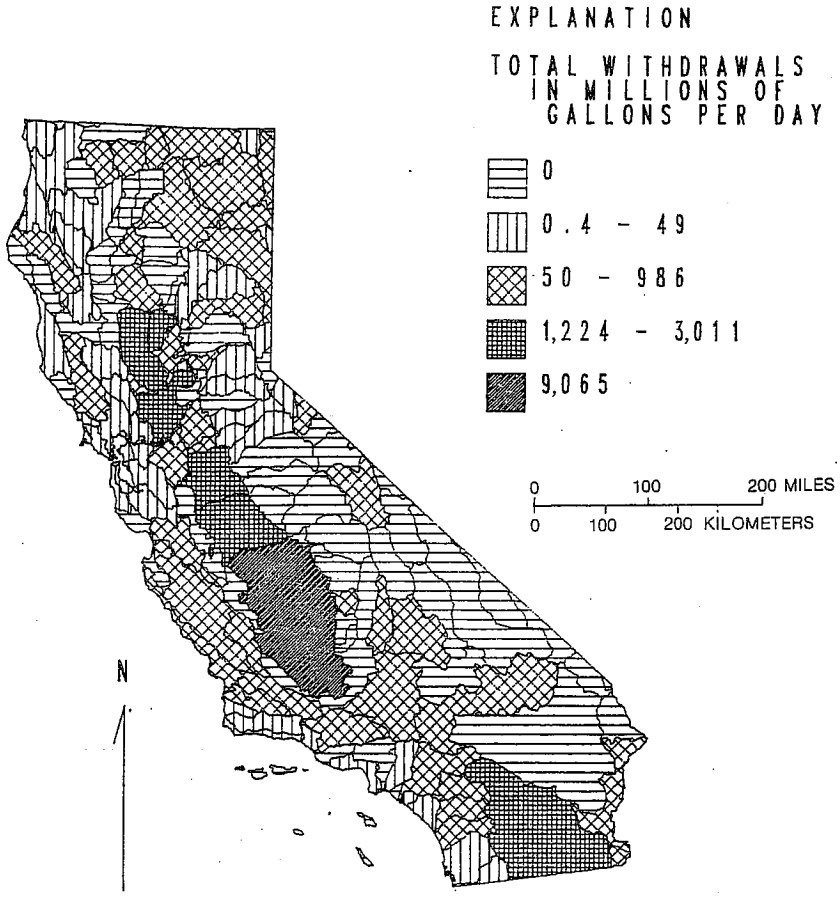

FIGURE 3. Irrigation Water Use in California, 1985, by Hydrologic Cataloging Unit.

CONCLUSION

The application of GIS technology is a logical progression in the development, analysis, and evaluation of computerized data bases. Computer software and hardware allow much more rapid manipulation of large volumes of data than has been possible in the past. The continuation and expansion of this process seems natural to the solution of quality control and data synthesis problems when a large set of information is available from many different sources.

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